MODIS DATA SYSTEM STUDY

TEAM PRESENTATION

July 29, 1988

AGENDA

1. EosDIS Architecture Review
2. MIDACC Planning and Scheduling Operations Concept
3. Level-1 Data Products Requirements
4. Action Items
5. Response to Action Item 7/8-2

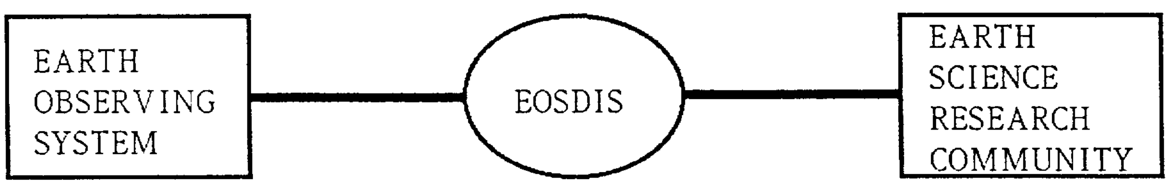
EosDIS ARCHITECTURE REVIEW

JULY 29, 1988

CONTENTS

1. EosDIS DEFINITION

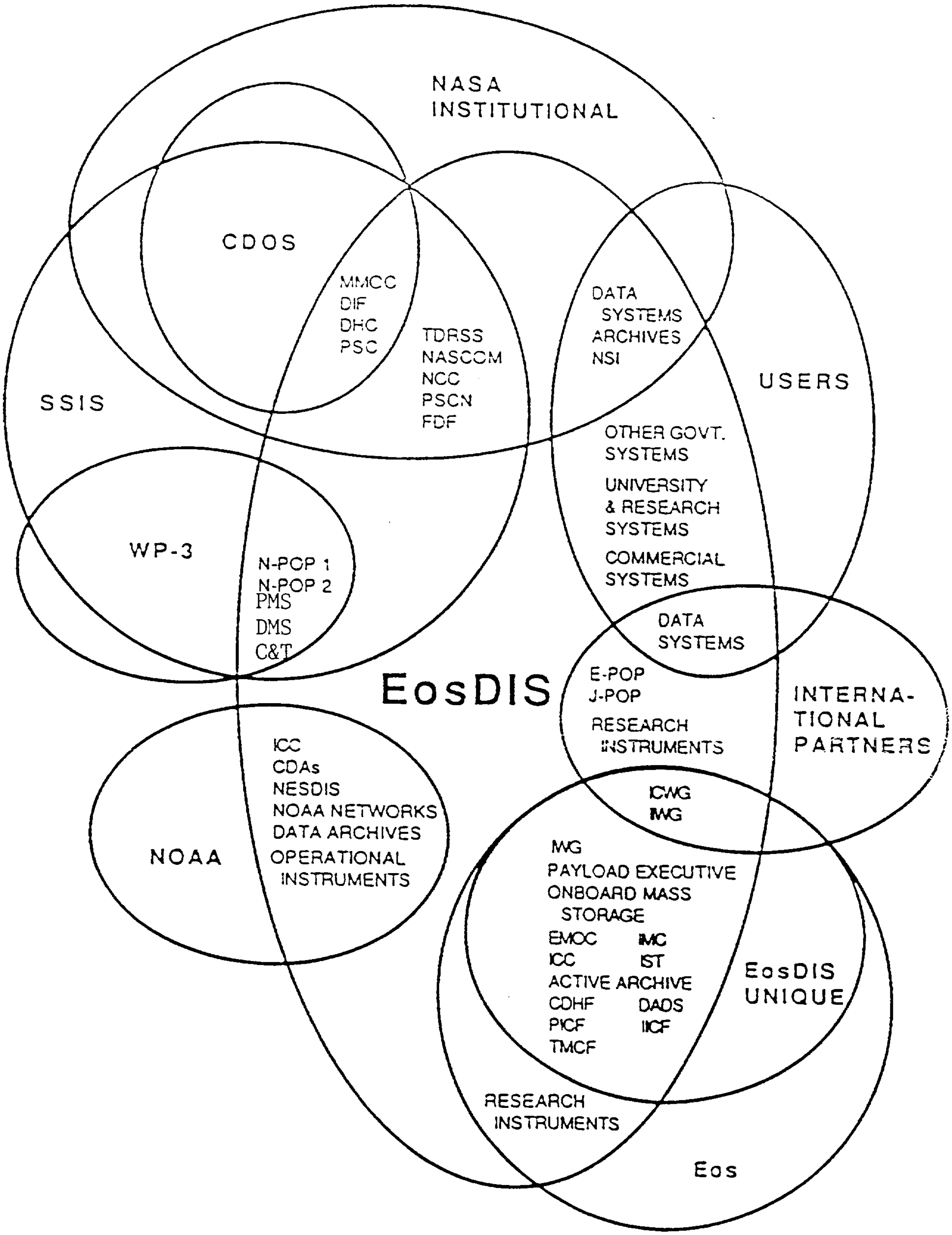
A COMPREHENSIVE DATA AND INFORMATION SYSTEM TO PROVIDE THE EARTH SCIENCE RESEARCH COMMUNITY WITH ACCESS TO FULL SUITE OF EARTH SCIENCE DATA FROM U.S. AND INTERNATIONAL PARTNER PLATFORMS



2. EosDIS ELEMENTS AND BOUNDARIES

- WILL BE DEVELOPED AND OPERATED IN THE CONTEXT OF NATIONAL AND INTERNATIONAL SPACE STATION ERA PROGRAMS

- WILL SHARE FUNCTIONALITY AND FACILITIES WITH PLANNED AND EXISTING INSTITUTIONAL FACILITIES OPERATED BY NASA AND NOAA, AND OTHER SYSTEMS OR ORGANIZATIONS

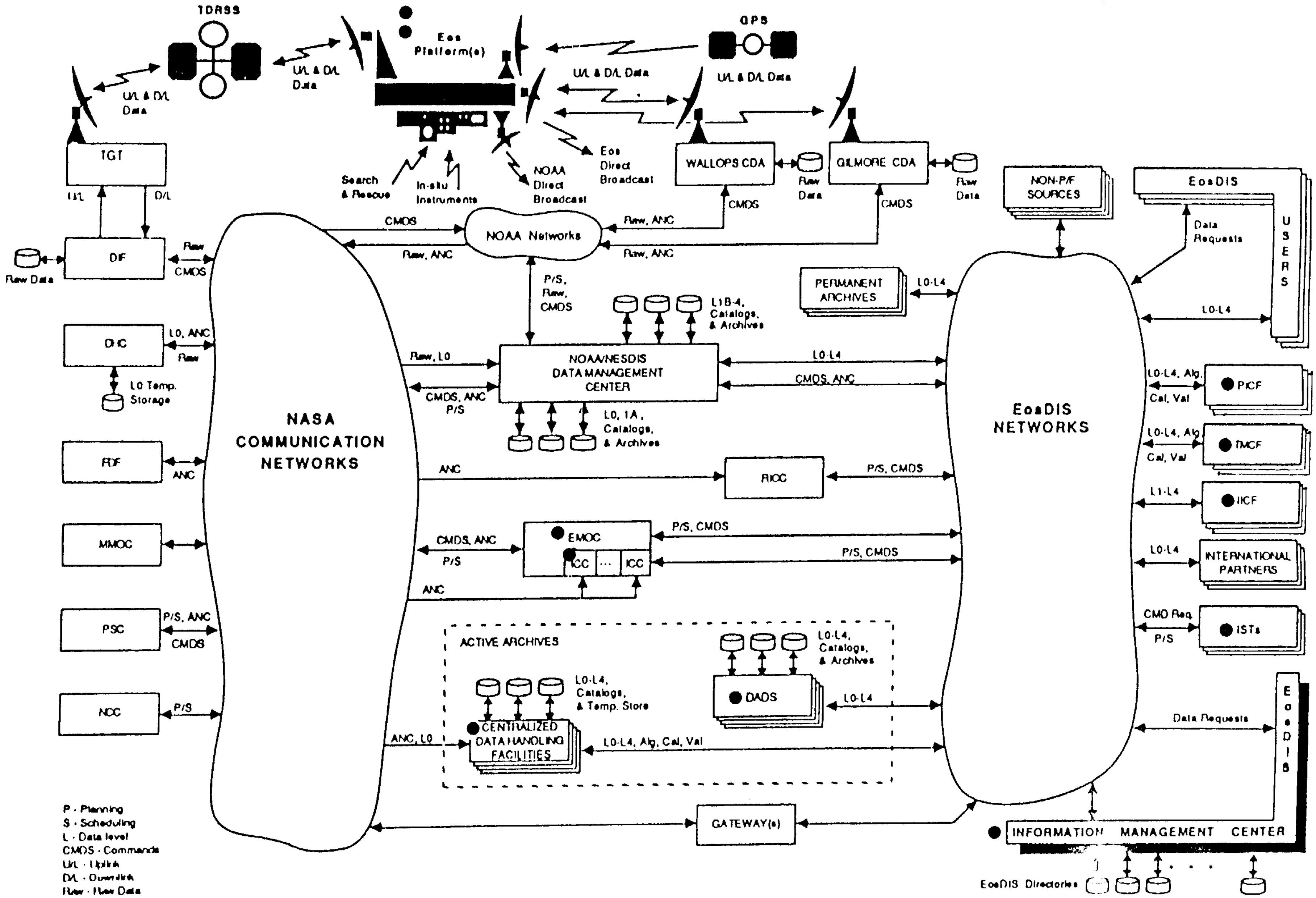


NASA
INSTITUTIONAL
CDOS
MMCC
DIF
DHC
PSC
TDRSS
NASCOM
NCC
PSCN
FDF
DATA
SYSTEMS
ARCHIVES
NSI
USERS
SSIS
OTHER GOVT.
SYSTEMS
UNIVERSITY
& RESEARCH
SYSTEMS
COMMERCIAL
SYSTEMS
WP-3
N-POP 1
N-POP 2
PMS
DMS
C&T
DATA
SYSTEMS
EosDIS
E-POP
J-POP
RESEARCH
INSTRUMENTS
INTERNA-
TIONAL
PARTNERS
ICC
CDAs
NESDIS
NOAA NETWORKS
DATA ARCHIVES
OPERATIONAL
INSTRUMENTS
NOAA
ICWG
IWG
IWG
PAYLOAD EXECUTIVE
ONBOARD MASS
STORAGE
EMOC
IMC
ICC
IST
ACTIVE ARCHIVE
CDHF
DADS
PICF
IICF
TMCF
EosDIS
UNIQUE
RESEARCH
INSTRUMENTS
Eos

3. EosDIS MAJOR FUNCTIONS

FUNCTIONS	EXECUTORS
MISSION PLANNING	ICWG/IIWG/IWG
MISSION OPERATIONS	PSC, MMOC/EMOC/ICC/IST
COMMANDING	PSC, EMOC/ICC/IST
COMMUNICATIONS	TDRSS, TGTs, NCC, NASCOM, PSCN, NOAA NETWORK, OTHERS
DATA ACQUISITION	DIF (CDA)
DATA PROCESSING	PAYLOAD EXECUTIVE, DMS, DHC, CDHF, TMCF/PICF/IICF
DATA STORAGE	ON-BOARD MASS STORAGE, DADS/PERMANENT ARCHIVES
DATA DISTRIBUTION	DADS (IMC)
INFORMATION MANAGEMENT	IMC
END-TO-END FAULT MANAGEMENT	(ALL)

4. EosDIS BASELINE ARCHITECTURE

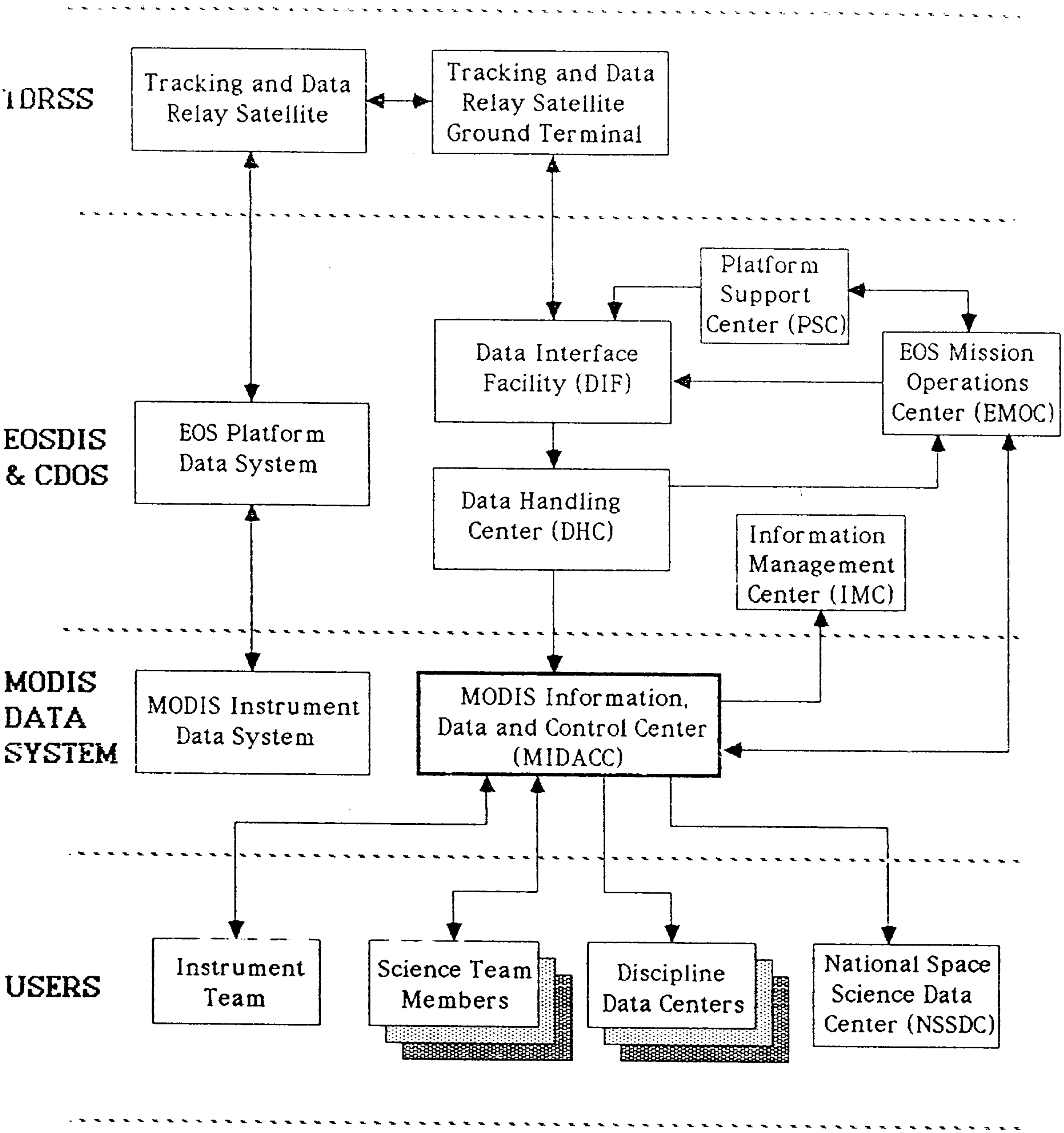


P - Planning
S - Scheduling
L - Data level
CMDS - Commands
U/L - Uplink
D/L - Downlink
Raw - Raw Data
ANC - Ancillary Data
Alg - Algorithms
Cal - Calibration Data
Val - Validation Data

March 9, 1988

EosDIS UNIQUE ELEMENTS

- PAYLOAD EXECUTIVE
- ON-BOARD MASS STORAGE
- EMOC
- IMC
- ICC
- IST
- ACTIVE ARCHIVE - CDHF AND DADS
- PICF
- IICF
- TMCF



The MODIS Data System in the EosDIS Environment

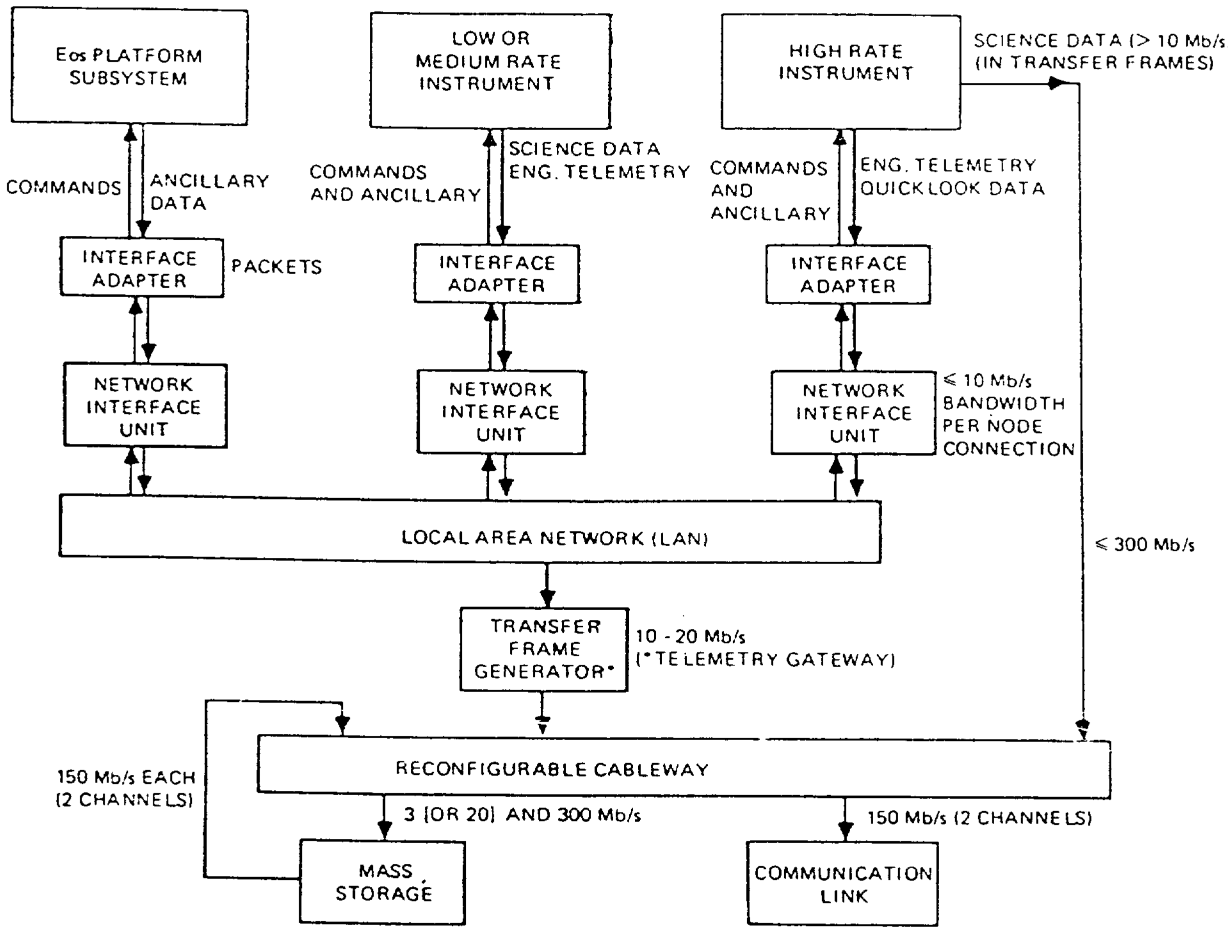
5. DESIGN PRINCIPLES

- LAYERING AND MODULARITY
  - CAN ACCOMMODATE CHANGING USER REQUIREMENTS OR TECHNOLOGICAL DEVELOPMENTS
  - DISPLAYS SIMPLE, WELL DEFINED SYSTEM INTERFACES THAT ARE TECHNOLOGICALLY TRANSPARENT
  - AVOIDS THE NEED FOR MAJOR ADVANCES IN TECHNOLOGY
- STANDARDIZATION
  - STANDARD DATA STRUCTURES PROMOTE DATA AUTONOMY

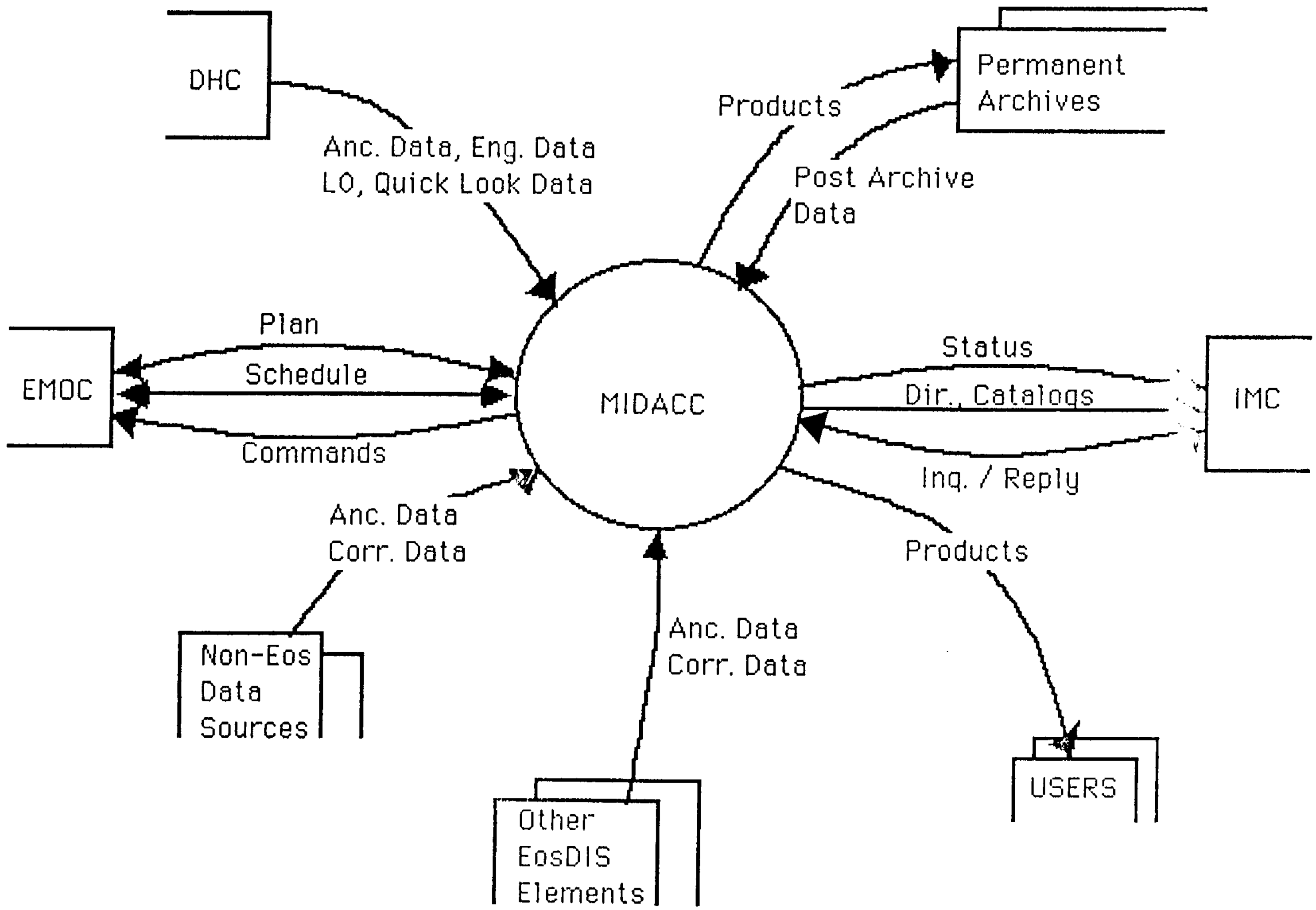
6. DESIGN CONSIDERATIONS/CONSTRAINTS

- EVOLUTION
- FLEXIBILITY AND CLARITY (OVER EFFICIENCY)
- USE OF EXISTING AND PLANNED ELEMENTS OF SSIS AND OTHER COOPERATING AGENCY RESOURCES
- USE OF STANDARDS (FOR DATA STRUCTURES, AND DATA INTERCHANGE)
  - ISO'S OPEN SYSTEM CONCEPT
  - CCSDS RECOMMENDATIONS

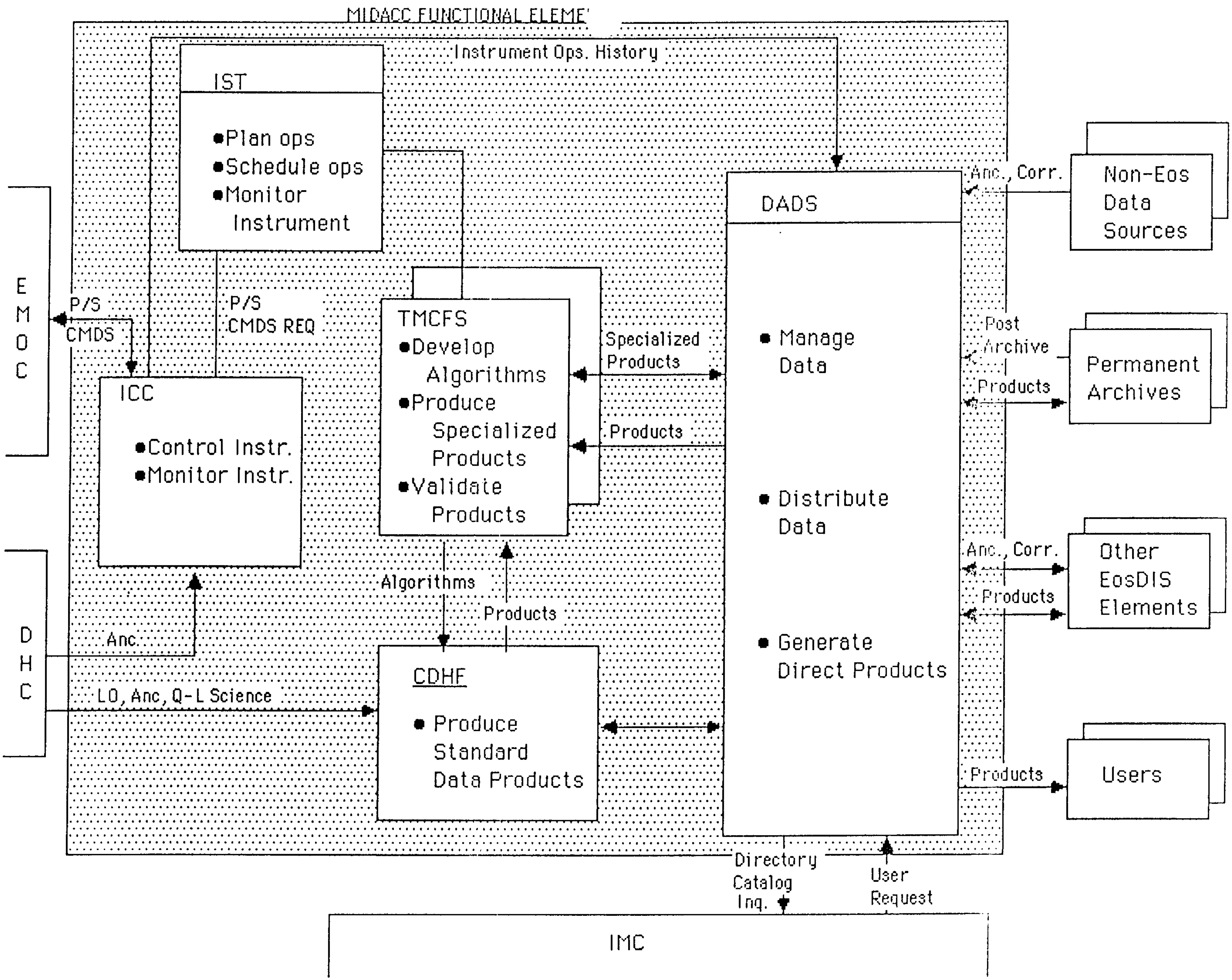
- RESOURCE BOTTLENECKS
  - COMMUNICATIONS LINK BETWEEN GROUND AND PLATFORM
  - ON-BOARD LAN
  - ON-BOARD MASS STORAGE
  - ON-BOARD PROCESSOR



Eos PLATFORM SUBSYSTEM
LOW OR MEDIUM RATE INSTRUMENT
HIGH RATE INSTRUMENT
SCIENCE DATA (> 10 Mb/s) (IN TRANSFER FRAMES)
COMMANDS
ANCILLARY DATA
COMMANDS AND ANCILLARY
SCIENCE DATA ENG. TELEMETRY
COMMANDS AND ANCILLARY
ENG. TELEMETRY QUICKLOOK DATA
INTERFACE ADAPTER
PACKETS
INTERFACE ADAPTER
INTERFACE ADAPTER
NETWORK INTERFACE UNIT
NETWORK INTERFACE UNIT
NETWORK INTERFACE UNIT
≤ 10 Mb/s BANDWIDTH PER NODE CONNECTION
LOCAL AREA NETWORK (LAN)
≤ 300 Mb/s
TRANSFER FRAME GENERATOR*
10 - 20 Mb/s (*TELEMETRY GATEWAY)
RECONFIGURABLE CABLEWAY
150 Mb/s EACH (2 CHANNELS)
3 (OR 20) AND 300 Mb/s
150 Mb/s (2 CHANNELS)
MASS STORAGE
COMMUNICATION LINK



MIDACC CONTEXT DIAGRAM


MIDACC FUNCTIONAL ELEME'
Instrument Ops. History
IST
●Plan ops
●Schedule ops
●Monitor Instrument
E M O C
P/S CMDS
P/S CMDS REQ
ICC
●Control Instr.
●Monitor Instr.
TMCFS
●Develop Algorithms
●Produce Specialized Products
●Validate Products
Specialized Products
Products
DADS
● Manage Data
● Distribute Data
● Generate Direct Products
Anc., Corr.
Non-Eos Data Sources
Post Archive
Products
Permanent Archives
Anc., Corr.
Products
Other EosDIS Elements
Products
Users
Algorithms
Products
D H C
Anc
LO, Anc, Q-L Science
CDHF
● Produce Standard Data Products
Directory Catalog Inq.
User Request
IMC

7/29/88

MIDACC PLANNING AND SCHEDULING OPERATIONS CONCEPT

MOTIVATION: 1) Develop planning and scheduling concept for MODIS and evaluate how the function will be performed.
2) Generate functional requirements for the MIDACC.
3) Provide input to the preliminary architecture studies.

SCOPE: This deliverable focuses on defining planning and scheduling operations for MODIS. Emphasis is placed on the ICC facility and its relationships with EOSDIS and MIDACC elements. From the high level context diagram, more detailed diagrams are broken out between the ICC and other elements showing functions, data flows, and probable decisions. As more detailed concepts are developed, subsequent versions of this operation concept will be revised and expanded to include other MIDACC responsibilities and expected performances.

MIDACC PLANNING AND SCHEDULING OVERVIEW: A high level context diagram, shown in the first figure, presents the elements involved in general MIDACC planning and scheduling operations. The MIDACC elements to be emphasized here are the ICC, IST, and CDHF. In this figure, the DHC will receive MODIS data and provide it to the MIADCC as raw or level zero (L0) data. The raw data, either real-time or playback, is sent to the ICC for monitoring MODIS state-of-health (SOH). L0 data is send to the CDHF for higher level processing and subsequent storage in the DADS. The IST will provide a conduit for the Team Leader to request observations and to receive information about instrument performance and the feasibility of the request. The ICC planning and scheduling functions, shown by the shaded regions, are discussed below.

At the beginning-of-life (BOL) of MODIS, an agreement will have been reached at the level of EMOC and higher as to the platform resource envelope (e.g. power and thermal) to be allocated to MODIS operations and as to the overall science plan and objectives for MODIS. The first operational schedule implemented by MODIS will be consistent with the master plan. The discussion which follows is directed more towards the routine planning and scheduling maintenance of this plan consistent with platform capabilities.

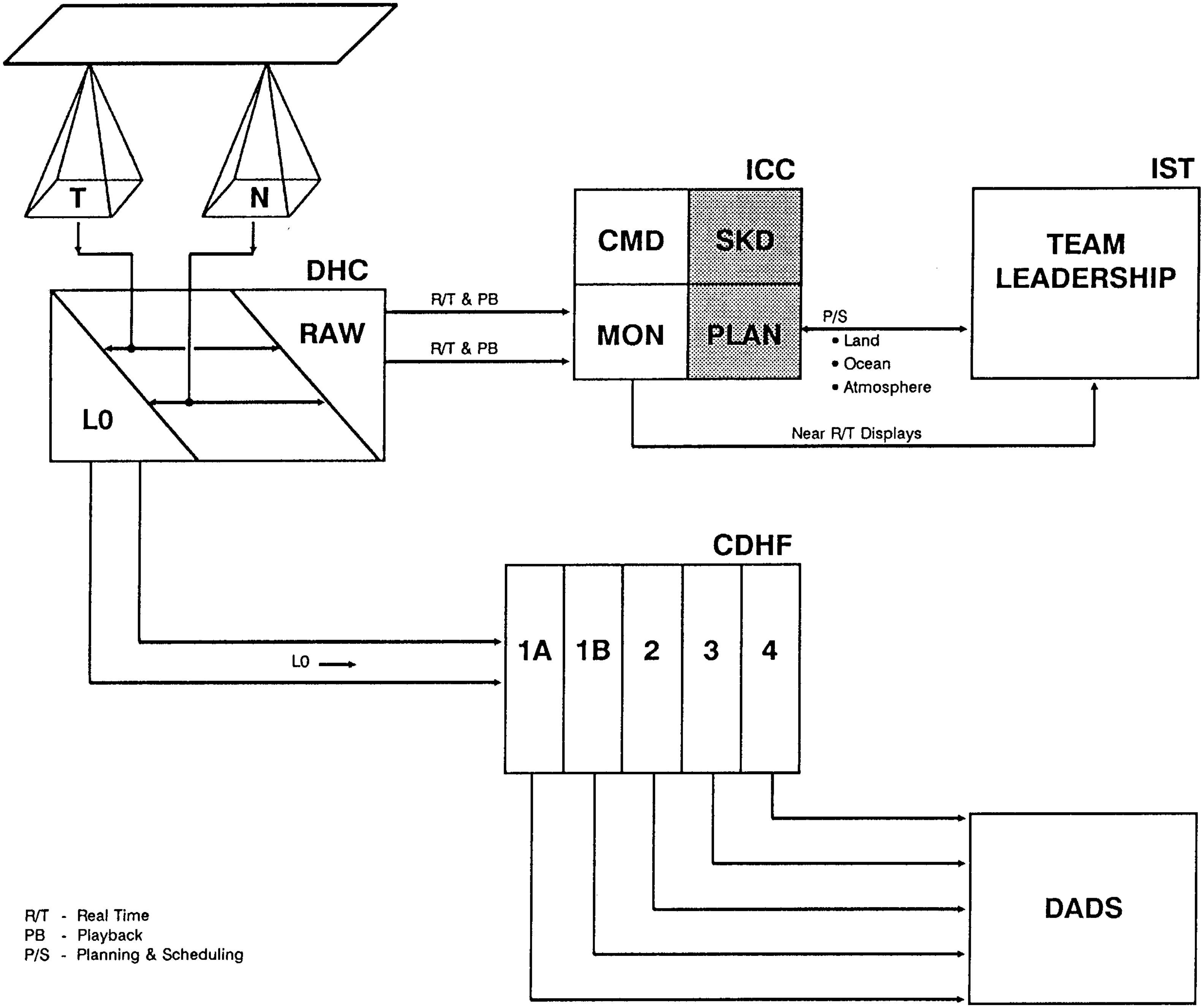
ICC PLANNING AND SCHEDULING FUNCTIONS: The second figure is a context diagram showing only the planning and scheduling operations of the ICC. It presents the ICC interface with EOSDIS and MIDACC elements. A simulator is introduced at this level to aid in the ICC planning and scheduling operation. The planning and scheduling concept is as follows.

The planning process takes high level observation request and generates a candidate schedule of instrument operation. This process would be completed about 1 month prior to command loading. The scheduling process continues for approximately 3 weeks. The schedule is iterated with the EMOC until approval about 1 week prior to command loading.

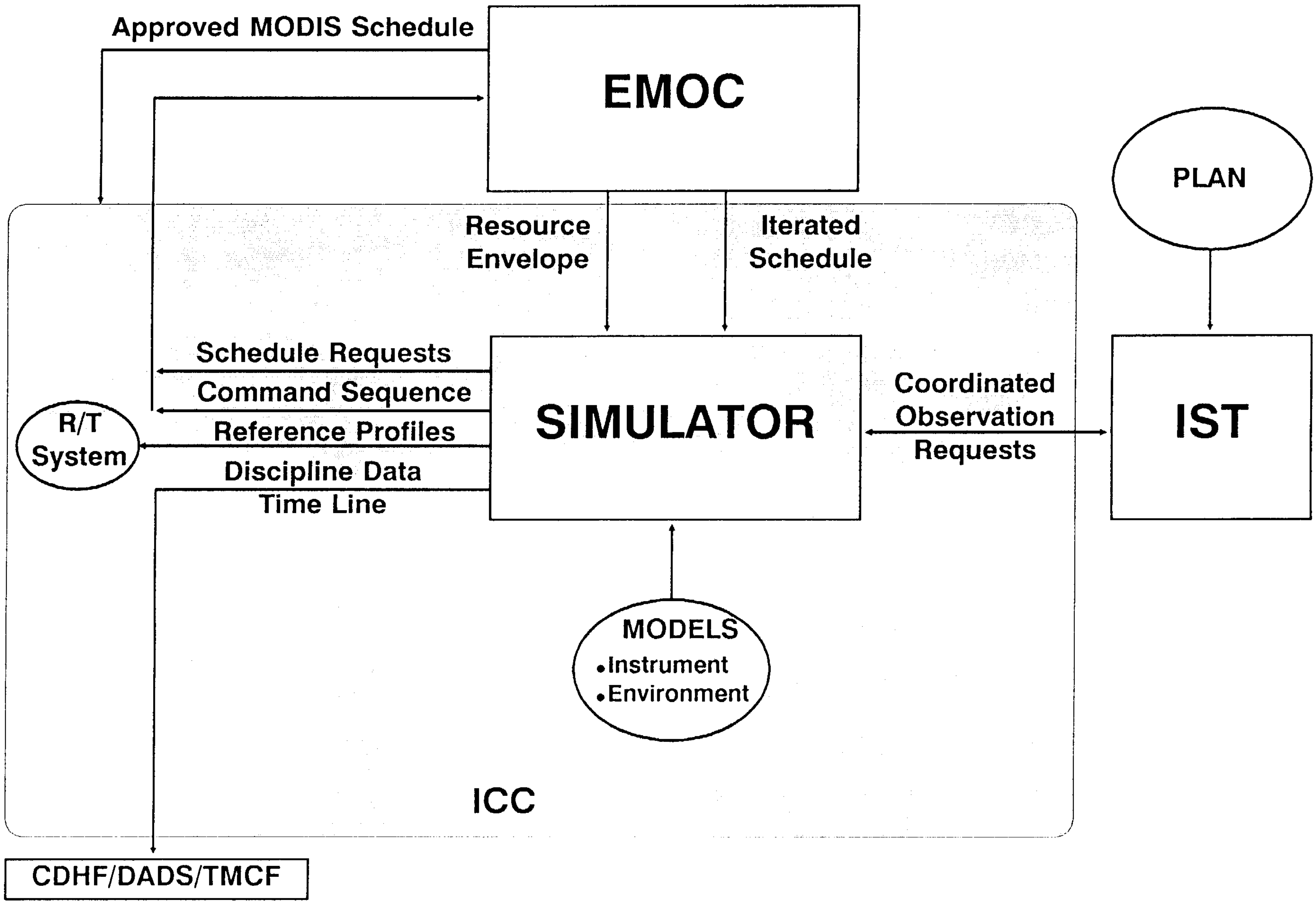
Scheduling begins with an observation request by the IST. The ICC will use the request and the instrument and environmental models as input to simulate the MODIS resource requirements and performance. A comparison will be made to the EMOC provided resource envelope which consist of resource constraints, guidelines, and ephemeris data. The ICC will then provide the EMOC will a schedule request that observes the allocated resource requirements for MODIS. The EMOC will coordinate this request with other EOSDIS elements to determine if this schedule request conflicts with available resources. If conflicts are present which affect MODIS, the EMOC will iterate the schedule with the ICC until a conflict free schedule is produced. The ICC will then send the command sequence to the EMOC for transmission to MODIS. The ICC will also generate reference profiles that will be utilized in the real-time monitoring function and discipline data timelines for use by other MIDACC elements.

ICC PLANNING AND SCHEDULING SIMULATION: The third figure shows the functions of the ICC simulator. Observation request are passed through an interface to convert the request to a usable form. These requests are checked against environmental models (orbit, attitude, Sun, and Scene) to determine the feasibility of the request. After passing this check, the instrument is modeled to see if the request results in violating the allocated resources. If either of these checks fail, the ICC will inform the IST of the failure. After passing the above tests, the ICC will generate a schedule request, a command sequence, the reference monitoring profiles, and discipline data timelines. The schedule request is sent to the EMOC for iteration and approval. In the case were conflicts exist, the EMOC will send the ICC an iterated schedule with possible changes to the available resources for MODIS. The process of simulating the MODIS instrument is again performed and a new schedule request is sent to the EMOC. This iteration will take place until an approved MODIS schedule is resolved. If conflicts are not present, the EMOC will send an approved MODIS schedule to the ICC at which time the ICC will release the command sequences to the EMOC.

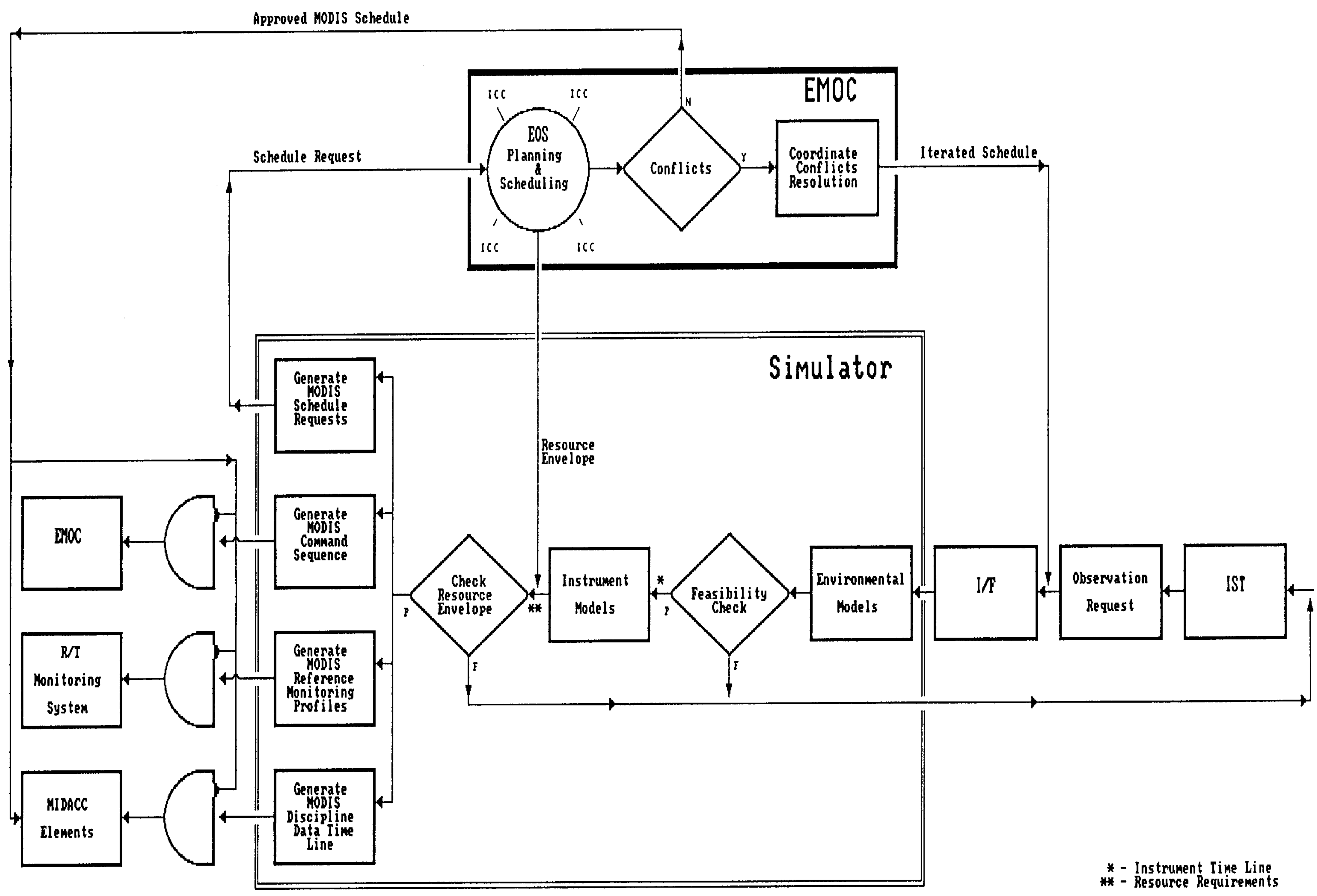
The remaining attachments have been presented earlier and represent candidate IST observation request to be made to the ICC. These "request" will now be used in further refining the planning and scheduling operations concept; in generating scenario specific command sequences ; and, in developing an instrument monitoring operations concept. These activities will contribute to refining MIDACC functional requirements, and to evaluating a preliminary MIDACC architecture.



R/T - Real Time
PB - Playback
P/S - Planning & Scheduling



ICC Planning & Scheduling Overview



Approved MODIS Schedule
EMOC
ICC
EOS Planning & Scheduling
Conflicts
N
Y
Coordinate Conflicts Resolution
Schedule Request
Iterated Schedule
Simulator
Generate MODIS Schedule Requests
Resource Envelope
Generate MODIS Command Sequence
Generate MODIS Reference Monitoring Profiles
Generate MODIS Discipline Data Time Line
EMOC
R/T Monitoring System
MIDACC Elements
Check Resource Envelope
Instrument Models
Feasibility Check
Environmental Models
I/F
Observation Request
IST
P
F
*
**
* - Instrument Time Line
** - Resource Requirements

3. Ocean chlorophyll and biological activity

3.1 Scientific objective

Real time maps of ocean chlorophyll and biological activity will be generated and later weekly and monthly mean maps will be compiled for at least 10 years.

3.2 MODIS-N channels required:

Channels 9 through 15.

Channels 35 and 36 of sea surface temperature.

3.3 MODIS-T channels required:

All with zero degree tilt pole to X1 degrees north, Y1 degree tilt fore between X1 and X2 degrees north, Y2 degree tilt fore between X2 and X3 degrees north, -Y2 degree tilt aft between X3 degrees north and X4 degrees south, -Y1 degree tilt aft between X4 degrees south and X5 degrees south, and zero degree tilt between X5 degrees south and south pole. Nota: values of X1 to X5 and Y1 and Y2 can be expected to be different each orbit. This procedure avoids sun glint problems.

3.4 Other Eos instruments required:

HIRIS in regions and times to be specified.

3.5 Time required: Within 48 hours of acquisition.

3.6 Other requirements:

Radiometric accuracy of 0.25% is required.

Resolution of radiometric data to 15 bits is required so amplifier gain will be set such that the instrument will saturate when reflectance is 50% or greater.

Level 3 maps will have a 20km. resolution.

Only data over oceans and lakes with clear sky conditions are needed.

In-situ data from 10 to 100 buoys will need be merged with the MODIS data products.

Ten years of continuous data are required.

One scientist also has a requirement to look for biolumenesence in the East Indies at night. This requires MODIS-T channels 4 and 28 (possibly others) be put in a stare mode to look at one region at night. The region and date will be determined by in-situ ship board observations. Calibrated radiance data is required in real time. Assume this is feasibility study to see if a signal can be detected, which may lead to a monitoring study.

4. Special study of cloud top heights

4.1 Scientific objective:

All methods of determining cloud top heights will be compared, particularly comparing those methods that are sensitive to accurate instrument calibration to those methods that are calibration independent.

4.2 MODIS-N channels required:

Channels 14,15,16,22,23,35,36,37,38,39,40.

4.3 MODIS-T channels required:

All.

4.4 Other Eos instruments:

LASA cloud top height measurements.
AMRIR cloud top height and temperature measurements.
HIRIS cloud top height and temperature measurements.
All co-located in space and time.

4.5 Time needed:

One week of data, every 6 months, during entire mission, delivered within one month of acquisition.

Other requirements:

For MODIS-T each region must be viewed from nadir position and from two angles such that there is a 6 degree separation between the two views so that stereo images can be formed. The maximum number of regions which can be viewed should be viewed independent of sky conditions.

Special runs with angular separations of 8,10, and 12 degrees will also be made, with at least one day of data in each mode.

250 meter resolution is preferred.

Also would like to acquire co-located cloud top heights from GOES satellite for intercomparison purposes.

If an explosive volcanic eruption goes off and MODIS will soon observe that region of the Earth, then assume this cloud height program will become operational to measure the volcanic plume height.

MODIS LEVEL-1 DATA PRODUCTS REQUIREMENTS

These requirements are presented for review. They contain assumptions which may be changed as the overall requirements of the MODIS Information, Data, and Control Center (MIDACC) are refined and additional requirements are identified. Further development of the higher-level processing requirements will enable these requirements to be stated more precisely and with fewer assumptions.

Requirement 1: Level-1 products shall contain all of the information necessary for the creation of catalogs and inventories of Level-1 data, and this information should be passed on to the next level of processing. **Considerations:** This information should be readily accessible in the form of a header file or record (at the beginning of the volume in the case of sequential storage media). If random-access storage media are used, then the header could contain addresses enabling the user to conveniently access orbits and/or time blocks of the data.

Requirement 2: It is assumed that the level-0 processor will eliminate redundancies, perform data quality checking, perform error corrections, and organize the data in chronological order by orbit. **Considerations:** This is a requirement for level-1 data that should already have been satisfied by the level-0 processing.

Requirement 3: MODIS-N AND MODIS-T data shall be processed to level-1A separately, i.e., there shall be separate N and T level-1A products. **Considerations:** When the requirements for higher-level processing become better defined, it will be possible to define standard level-1B products which may be a mixture of MODIS-N and MODIS-T level-B data; for example, the level-2 processor for ocean chlorophyll will certainly require both MODIS-N and MODIS-T data in order to obtain full coverage when the tilt of MODIS-T is changed.

Requirement 4: Until reversibility of the calibration process is demonstrated, it is assumed that both level-1A and 1B products will be produced and archived.

Requirement 5: All data shall be processed to level-1A.

If users will be able to request subsets of level-1 data, then will these subsets be considered standard ("legitimate") level-1 products?

Requirement 7: The basic level-1 product time span is TBD, but may be multi-day, daily, orbital, divided by fraction of a day, etc. **Considerations:** The time span will be a trade-off between the capacity of storage media to save the MODIS data (10^{12} bits per day at level-1) and the user's requirements.

Requirement 8: The word size for the level-1 data products is TBD. The volume of the archived data set could be kept at a minimum by retaining the data at the bit word size coming from the instrument. **Considerations:** Packing the instrument data in 12-bit words will save 25% to 33% of the storage capacity utilized by the same information supplied in more convenient 16-bit words.

Requirement 9: The level-1 data products shall have appended to the basic product the following ancillary data:

A. MODIS-N/MODIS-T sensor identification.
B. Product sequence number / version number.
C. Processing date.
D. Processing software version number.
E. Calibration algorithm identification number / version number.
F. Product start and stop time.
G. Orbit number(s).
H. Geographical boundaries of the product (e.g., target areas involved in the coverage of the product).
I. Channel identifications.
J. Data quality flags.
K. Calibration quality flags.
L. Housekeeping data.
M Engineering data.

Considerations: It is assumed that, if portions of the basic data product are ordered, this basic header/trailer documentation will be supplied to the user.

Requirement 10: The level-0 or level-1 processor shall organize the science data

Requirement 10: The level-0 or level-1 processor shall organize the science data into logical data records that consist of the scan lines for the respective instrument (8 km by 1500 km for MODIS-N and 64 km by 1500 km for MODIS-T). **Considerations:** This is consistent with the logical data records defined for the Coastal Zone Color Scanner, and were recommended in an earlier Phase-A study of the MODIS level-1 processing requirements.

Requirement 11: The level-1 products shall have appended to each logical data record the following information:

A. Geographic location.
B. Land/ocean flags.
C. Measure of cloudiness.
D. Channel identifications.
E. Instrument tilt information (MODIS-T).
F. Instrument temperatures.
G. Scan number.
H. Attitude information.
I. Platform ephemeris.
J. Time code.
K. GPS time correction.
L. Platform structure telemetry.
M. Calibration coefficients.
N. Calibration quality flag.
O. Data quality indicators.
P. Start and stop times.

Requirement 12: Each logical data record shall be divided into data segments, e.g., each scan could be divided into five equal scan angle segments. Final segmentation is TBD.

Requirement 13: The level-1 products will include the following information appended to each data segment:

A. Time tags.
B. Geographic locations.

C. Solar zenith and satellite zenith angles.

D. Land/ocean flag.

E. Measure of cloudiness.

Considerations: Given the large number of pixels per scan line, introducing some small measure of partially redundant parameters for the convenience of the users will not significantly alter the total data volume.

Requirement 14: There shall be a separate calibration level-1A and 1B data product which will consist of data taken during calibration modes, i.e., when the sensor views the diffuser plate, calibration black bodies, etc. Calibration coefficients and calibration quality flags shall be appended to this calibration product.
Considerations: This product is designed to facilitate the timely analysis of MODIS sensor data for the determination of instrument-dependent characteristics such as gain and offset changes.

ACTION ITEMS:

7/8-1 (Ardanuy/Kim) Review the factors associated with assuming a 40% (or other) oversampling, as well as for calibration, housekeeping, and other engineering data, as they bear on the MODIS data rates and volume. ** Closed **

7/8-2 (Sharts) Investigate the effect, if any, that real-time and possibly redundant data transmissions will play in determining the MODIS data rates and volume.

7/8-3 (Han) Review the draft data product questionnaire with members of the MODIS Instrument Team.

7/15-1 (Han) Confirm the 10 and 20 megabit per second data rates projected for low data-rate instruments and the platform LAN.

AI 7/8-2 (Sharts)

Investigate the effect, if any, that real-time and possibly redundant data transmissions will play in determining the MODIS data rates and volumes.

SUMMARY

ASSUME:

1. All MODIS channels are on all the time at full resolution providing a composite 20Mbps.

2. All MODIS data goes to the on-board recorder(s) for future playback.

$$20\text{Mbps} * 86400\text{s/d} * 365.25\text{d/y} = 6.3 \times 10^{14}\text{bpy}$$

3. One real-time TOO per month for science interpretation (as opposed to instrument monitoring) to level 1B.

4. The real-time science observation period will be 15 minutes (900 seconds).

$$20\text{Mbps} * 900\text{s} * 1\text{mo}^{-1} * 12\text{ mo/y} = 2.16 \times 10^{11}\text{bpy}$$

Note that this real-time (R/T) observation is also recorded for future playback (PB). Therefore the MIDACC will process

$$\frac{6.3 \times 10^{14} + 2.16 \times 10^{11}}{6.3 \times 10^{14}} * 100 = 100.034\% \text{ of the data.}$$

HOWEVER

This data volume would seem to have negligible impact on the MIDACC. Indeed, if we were to take 100 TOO's per month, the MIDACC would still only be processing 103% of the data.

The problem comes in considering the processor (machine) requirements to accommodate the science in real-time. Section 6 of the EOSDIS Baseline Report (see attachments) provides some guidelines on estimating computing power. Specifically, to elevate raw R/T MODIS data to level 1B requires

20Mbps(Raw) * 12(L1B)/0.7 = 343MIPS (* 3 = 1029MFLOPS).

As shown in Table 6.3-3, this should be doable with today's supercomputers. Another conclusion which now becomes clear is that such data must be processed first by the CDHF and then distributed to the R/T destination. Note: the "12" above refers to the path length given in Table 6.3-5 for level 1B; the "0.7" refers to a 70% processor utilization factor and the "3" is the multiplicative factor to calculate MFLOPS.

For R/T science monitoring, a more reasonable approach and more effective use of the CDHF computer may be to elevate only <u>one</u> MODIS channel <u>at a time</u>, in real-time, to level 1B. Please see the context diagram for the CDHF R/T Processor.

ASSUME:

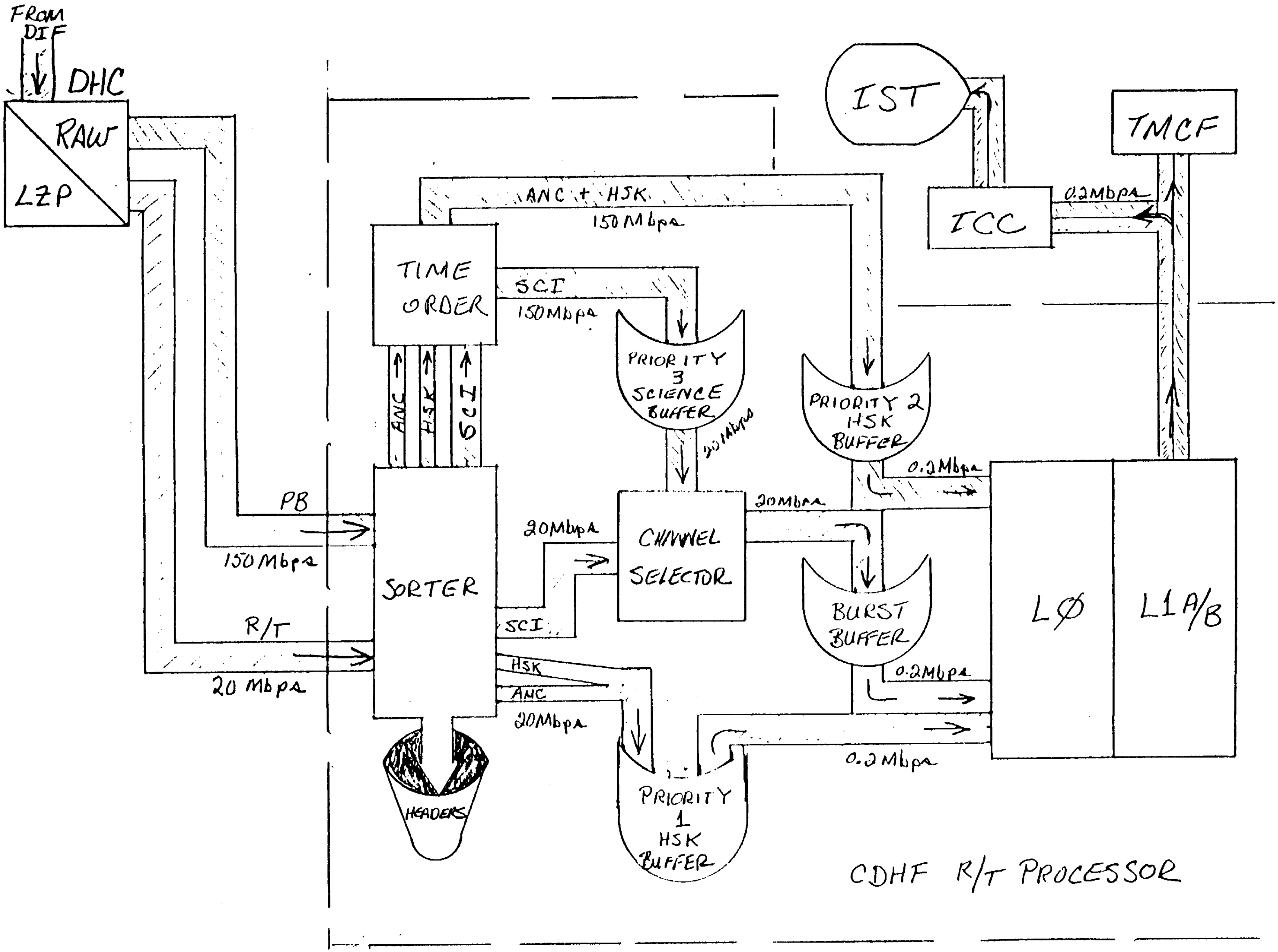
5. The DHC cannot do the sorting and channel selection on RAW data.

6. The sort and buffer process has a path-lengh of 3.

The MIPS requirement for the sort and buffer process is:

20Mbps(RAW) * 3(sort/buffer)/0.7 = 86MIPS (* 3 = 258MFLOPS)

Note that this appears to be a more reasonable tax on the supercomputer. Note also that while the bit rate of the selected channel is still 20Mbps, there is only one channel of about 100 going into the burst buffer. Therefore, the selected channel may be metered out of the buffer at 1/100 the rate (0.2Mbps) and still be in R/T. The MIPS requirement to elevate the selected channel to level 1B is:



CDHF R/T PROCESSOR

$$0.2\text{Mbps(RAW)} * 12\text{(L1B)}/0.7 = 3.4\text{MIPS} \ (* \ 3 = 10.2\text{MFLOPS})$$

which is just 1% of the earlier calculation.

The channel selection process would be made flexible and accommodative by the capability to pre-program and/or real-time override from the ICC (possible control interface).

ASSUME:

7. The store and display process has a path-length of 3.

The machine requirements at the receiving end (ICC/TMCF(?)) may be calculated:

$$0.2\text{Mbps(L1B)} * 3\text{(store/display)}/0.7 = 0.9\text{MIPS}$$

As seen in Table 6.3-1, todays super-mini's should be able to accommodate this concept.

Now, to re-visit the Summary estimate, although the front-end of the CDHF R/T Processor must look at and sort all MODIS channels, only about 1% (one channel of 100) of the data gets elevated to level 1B in real-time (according to this scenario). The total amount of all data processed then is:

$$\frac{6.3 \times 10^{14} + 2.16 \times 10^{9}}{6.3 \times 10^{14}} * 100 = 100.0034\% \text{ of all data}$$

CONCEPT
Routine ICC Monitoring

Since this volume of data is so small, why not have the ICC examine a select number of MODIS channels in real-time during every TDRS contact??? The effect of this would be to multiply the previous calculation by about $850 \approx 2 \ \frac{\text{contacts}}{\text{rev}} * 14 \ \frac{\text{revs}}{\text{d}} * 30^{+} \ \text{d/mo}$ as follows:

$$\frac{6.3 \times 10^{14} + 2.16 \times 10^{9} * 850}{6.3 \times 10^{14}} * 100 = 100.29\% \text{ of all data.}$$

As to the processing of R/T data in real-time while simultaneously recording the same observation for later playback and processing, the effect would seem to be small.

Now that we've discussed R/T instrument monitoring, let's take a look at the other path in the figure, playback monitoring.

The playback data should consist of overhead information applied by the platform DMS (~13%), instrument HSK, instrument science (SCI) and ancillary (ANC). The period covered by a typical playback will be that between nominal TDRS contacts (~50 minutes). The total amount of data for 50 minutes is:

$$20\text{Mbps} * 3000\text{s} = 6 \times 10^{10}\text{b (total data)}$$

$$\text{less 13\% overhead} = 5.2 \times 10^{10}\text{b (science + HSK/ANC)}$$

ASSUME:

8. The combined data rate for HSK and ANC data is less than 20Kbps to the platform DMS.

The amount of HSK/ANC data collect ed in 50 minutes is:

$$20\text{Kbps} * 3000\text{s} = 6 \times 10^{7}\text{b}$$

At the indicated data rate of 0.2Mbps, it should take about 5 minutes to process, display and store this data.

ASSUME:

9. The MODIS monitoring priorities are as follows:

   1. R/T science and HSK/ANC
   2. PB HSK/ANC
   3. PB science

Concurrent with the RAW R/T processing, the CDHF will receive and process the RAW MODIS PB data. At 150Mbps, the taperecorder (TR) read-out (R/O) should take about 6 2/3 minutes. The MIPS requirement for the PB sort and buffer process is:

150Mbps(RAW) * 3(sort/buffer)/0.7 = 643MIPS(* 3 = 1929MFLOPS).

Given the volume of recorded science data, it will be possible to examine only about 1% of all the data for housekeeping monitoring purposes. This should be acceptable given the lower priority of monitoring science data. For the ICC, the important thing is to examine all the MODIS HSK data and given the data volumes and rates, this will be accomplished easily. Since the data rate input to the channel selector from the PB buffer is the same as for R/T data, the MIPS requirement is the same as before.

Again, a control interface between the ICC and the CDHF R/T Processor Channel Selector will enable the ICC to monitor relatively important events such as channel status changes, gain changes, tilt angle changes (instrument dynamics), etc.

A candidate MODIS montioring timeline is shown in the following figure.

ICC MODIS MONITORING

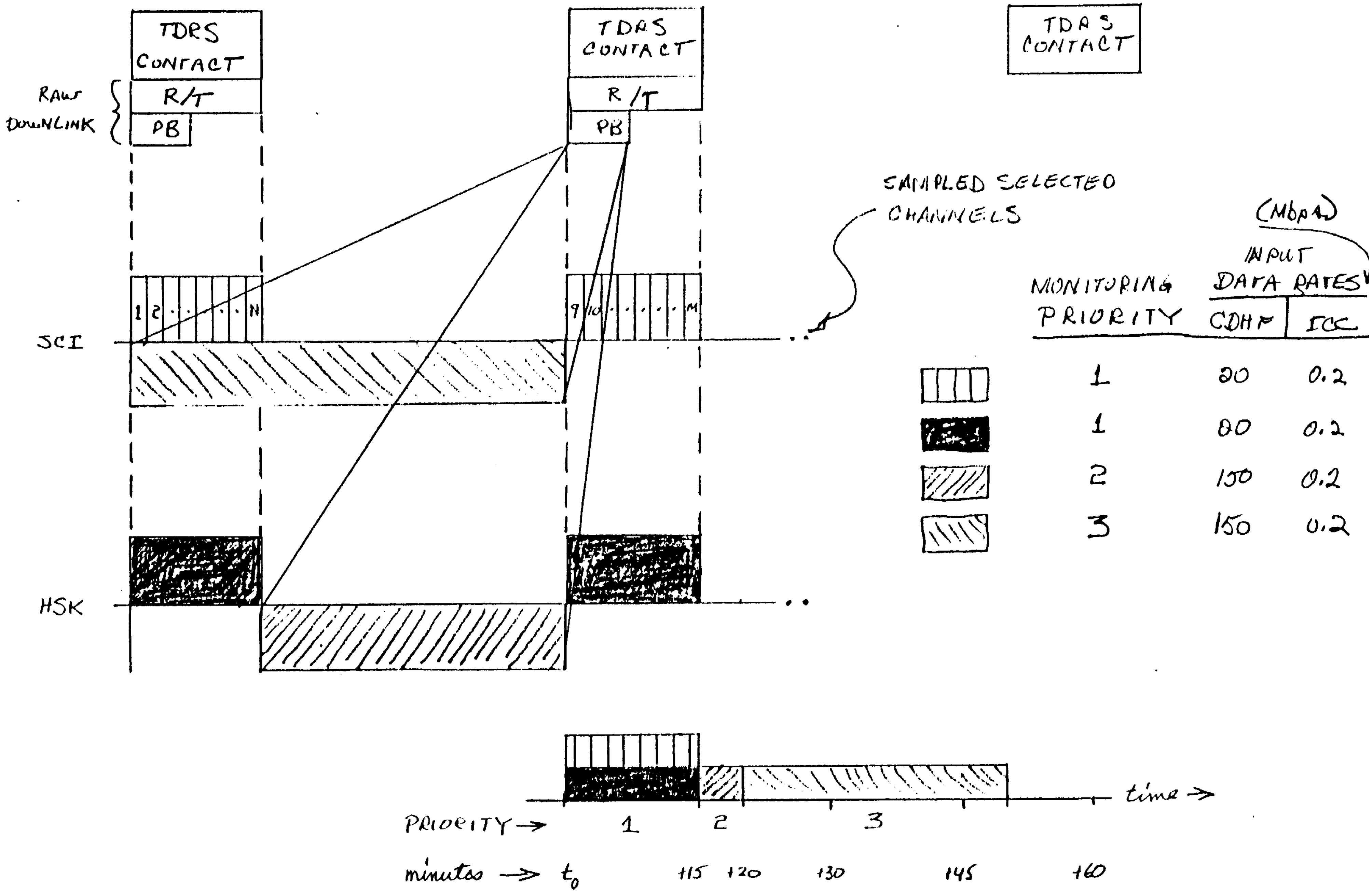


Table 6.3-1 Limited Survey of Available Super Mini-computers

Vendor	Model	MIPS	TRNS Rate (Mbps)	Cost
Convergent Technologies	Megaframe	5-.8	5-10	$30K - 125K
Data General	MV/4000	.6	5	$30K - 50K
Digital Equipment Corp	VAX 11/785	1.06	1.5-13.3	$145K and up
Digital Equipment Corp	8600	4.0		$576K - 970K
ELXSI	6400	6-60	64	$350K - 2M
Gould Inc.	Concept 31/8780	8.3	3.2	$425K - 1M
Harris Corp	H1000	4	19	$250K
IBM	4381	2.1-5.1	2-3	$806K - 1.9M
Perkin Elmer	3200MPS	5-21	40	$185k - 342K
Prime Computer	850		8	$2.7M and up
Tandem Computers Inc.	NonStop TXP-16	32	5	$1.7M and up

Table 6.3-2 Limited Survey of Available Mainframe Computers

Vendor	Model	MIPS	TRNS Rate (Mbps)	Cost
Amdahl	580 Series	7.6-23.0	72	$1.6 - 5.4M
Burroughs	A15	50		
IBM	308X	10-27	72	$0.6 - 6.4M
NAS	AS/90X0	6.6-21.0	60-96	$1.4 - 4.2M
Sperry Corp	1100/90	5.5-25.0	37	$2.9 - 8.9M
Sperry	1100/Mercury	100		

Table 6.3-3 Limited Survey of Available Supercomputers

Vendor	Model	MIPS	TRNS Rate (Mbps)	Cost
Amdahl	Model 1400	1140 MFLOPS		$12.5 - 21.8M
Control Data Corp	Cyber 205	740 MFLOPS	400	$4.9 - 12.5M
Cray Research	X-MP	560 MFLOPS	1346	$5 - 14M
Cray Research	Cray-2	1200 MFLOPS		$17.6M
ETA (Future)	ETA10	800 - 3200 MFLOPS		$5.5 - 12M
ETA (Future)	ETA10	4800 - 9600 MFLOPS		$13 - 22M

Table 6.3-5
Data Processing Rates and Required CPU MIPS for NPOP-1

	DATA PROCESSING RATES			REQUIRED MIPS	
	NASA LOW RATE	NASA HIGH RATE	PATH LENGTH	NASA LOW RATE (MIPS)	NASA HIGH RATE (MIPS)
RAW DATA					
Daily Data Volume (Mbytes)	78,572	108,000			
LEVEL 0 PROCESSING					
Raw Data Volume (Mbits)	628,576	864,000			
Level 0 Data Volume (Mbits)	880,006	1,209,600			
Level 0 Data Rate (Mbps)	10	14			
10% in Real Time (Mbps)	...	1	3	...	6
100% Process 8 hrs (Mbps)	...	42	3	...	180
Aggregate Rate (Mbps)	...	43	3	...	186
LEVEL 1A PROCESSING					
Data Volume (Mbits)	691,434	950,400			
100% Process 12 hrs (Mbps)	16	22	8	183	251
LEVEL 1B PROCESSING					
Data Volume (Mbits)	691,434	950,400			
100% Process 12 hrs (Mbps)	16	22	12	274	377
LEVEL 2 PROCESSING					
Data Volume (Mbits)	1,382,867	1,900,800			
100% Process 8 hrs (Mbps)	48	66	20	823	1,131
LEVEL 3 PROCESSING					
Data Volume (Mbits)	207,430	285,120			
100% Process 8 hrs (Mbps)	7	10	30	123	170